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**Space Weather Technical Forecast**

Issued on Saturday, 24 February 2024 at 00:41 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

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**Space Weather Forecast Headline: M-flares expected with a chance of X-flares. Chance of G1/Minor geomagnetic storm mainly on Day 2 (25 Feb). Slight but increasing chance of radiation storms.**

**Analysis of Space Weather Activity over past 24 hours**

**Solar Activity:** Solar activity has been Moderate over the past 24 hours, with the largest flare M2.6 peaking at 23/1747 UTC from AR3590 in the northeast, which was also recently responsible for the largest flare of the solar cycle so far. AR3590 remains, by far, the largest and most complex region. There has been rearrangement of the spots within its intermediate spot, with a couple of delta spots, but also some signs it may be increasing in complexity. There remains significant looping evident in SDO AIA imagery, with further large flares possible from this region. The remaining regions are much smaller and appear simpler, however, AR3591 close to the southeast limb likely contains the remnants of the previously active Ex-3575. This and two further regions close to the eastern horizon may reveal more complexity as they rotate into clear view on the disc.

No Earth directed CMEs were seen in the last 24 hours.

**Solar Wind / Geomagnetic Activity:** Solar winds, as observed by ACE at L1, have been at background levels. Speeds have been ambient, varying between 310-360 km/s. Density was average or below. Total magnetic field strength has been weak, below 7nT, with the north-south component varying weakly. Phi angle was largely positive (away from the Sun), but became more variable from around 23/0900 UTC. Geomagnetic activity was Quiet (Kp 0-1).

**Energetic Particles / Solar Radiation:** GOES18 high energy (greater than 10MeV) proton flux was very slightly above normal background levels, but well below the S1/Minor Radiation Storm threshold. Electron flux (greater than 2MeV) observed at GOES16 has been at normal background levels, with electron fluence well below the Active (1e8 integrated pfu) threshold. The observed 24-hour fluence at 24/0000UTC was 1.0e6 integrated pfu.

**Four-Day Space Weather Forecast Summary**

**Solar Activity:** Activity is forecast to remain Moderate to High, with occasional M-class flares expected and a chance of further isolated X-class flares, particularly in the near term, from AR3590.

**Solar Wind / Geomagnetic Activity:** There is the possibility of a glancing blow from a CME late on Day 1 (24 Feb) or early on Day 2 (25 Feb). Current solar winds are at background values but the high speed stream associated with CH01/- is expected to connect with Earth either later on Day 1 or more likely during Day 2. Peak wind speeds associated with this feature are likely to reach up to 500 km/s, before declining again from Day 3 into Day 4 (26-27 Feb). Geomagnetic activity is forecast to remain Quiet initially. An increase to Unsettled to Active is possible on Days 1 and 2, with a chance of G1/Minor storm intervals, particularly if connection to

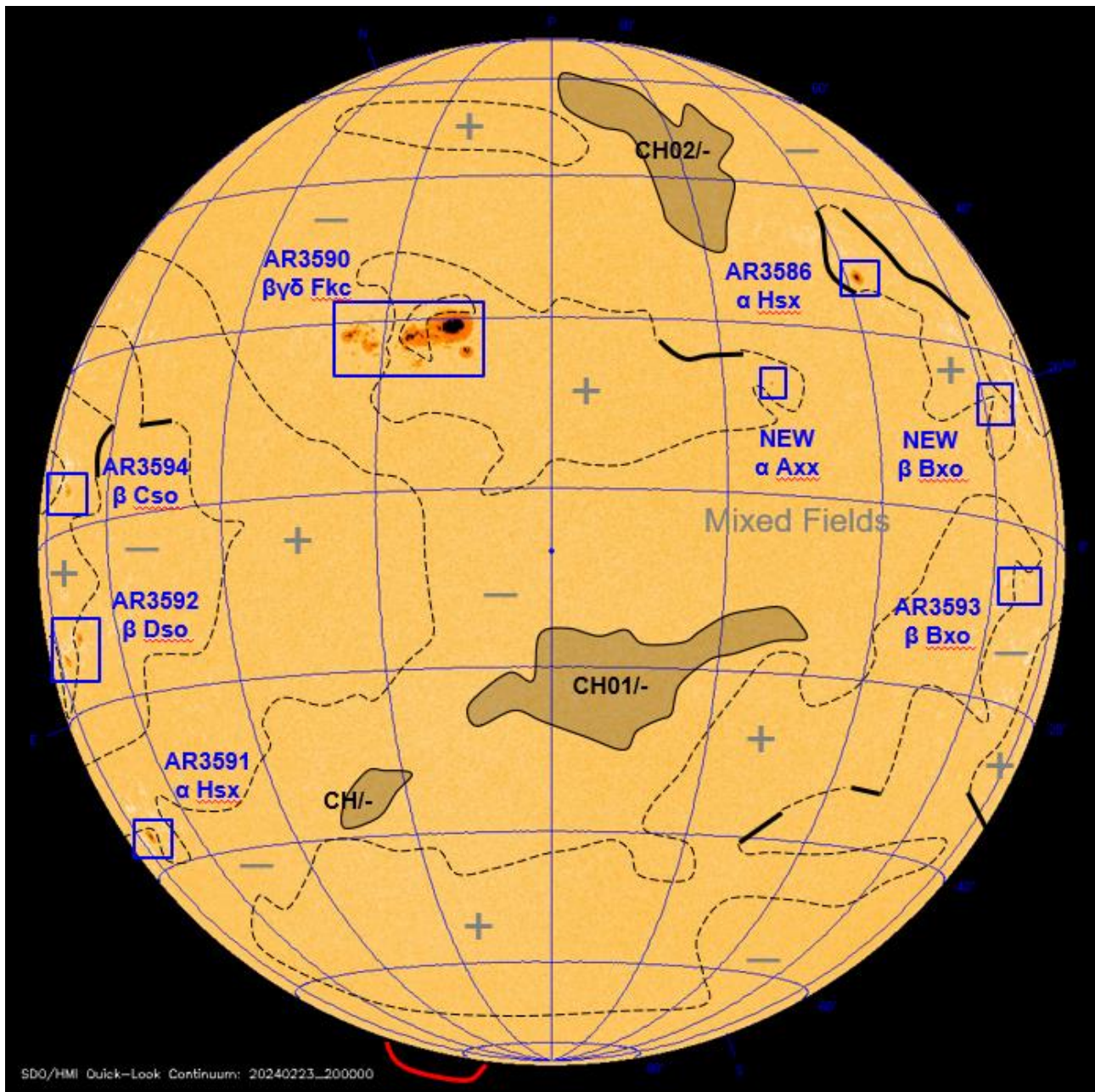
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the high speed stream and the glancing blow from the CME occur at similar times. Activity is then expected to decline through Day 3, becoming largely Quiet again by Day 4.

**Energetic Particles / Solar Radiation:** GOES18 high energy (greater than 10MeV) proton flux is likely to continue near background levels, but AR3590 will give an increasing risk of proton response as it moves into the western hemisphere of the Sun early on Day 2 (25 Feb), with a slight but increasing chance of S1/Minor Radiation Storms.

High energy electron flux (greater than 2MeV) is expected to remain at background levels at first, although an increase to moderate or high levels is possible later in the period. 24-hour electron fluence is expected to stay below the Active ( $1e8$  integrated pfu) threshold, perhaps on a rising trend, with a slight chance of reaching Active by Day 4 (27 Feb).

Figure 1. Solar Analysis Valid 23/2000 UTC.



**Key:** Filament —, Prominence —, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

**Geomagnetic Storms:**

A large filament was observed leaving the northwest of the disc around 21/1730UTC and is modelled to perhaps give a glancing blow late on Day 1 (24 Feb) or early on Day 2 (25 Feb). No other CMEs currently feature in the forecast.

Current solar winds are at background values but the high speed stream associated with CH01/- is expected to connect with Earth either later on Day 1 or more likely during Day 2. Peak speeds associated with this feature on the last rotation reached around 500km/s, with similar values considered likely. Geomagnetic response was fairly muted on the last rotation although the response on this rotation may be slightly stronger as we move closer to the March equinox. Wind speeds are expected to decline again from Day 3 into Day 4 (26-27 Feb).

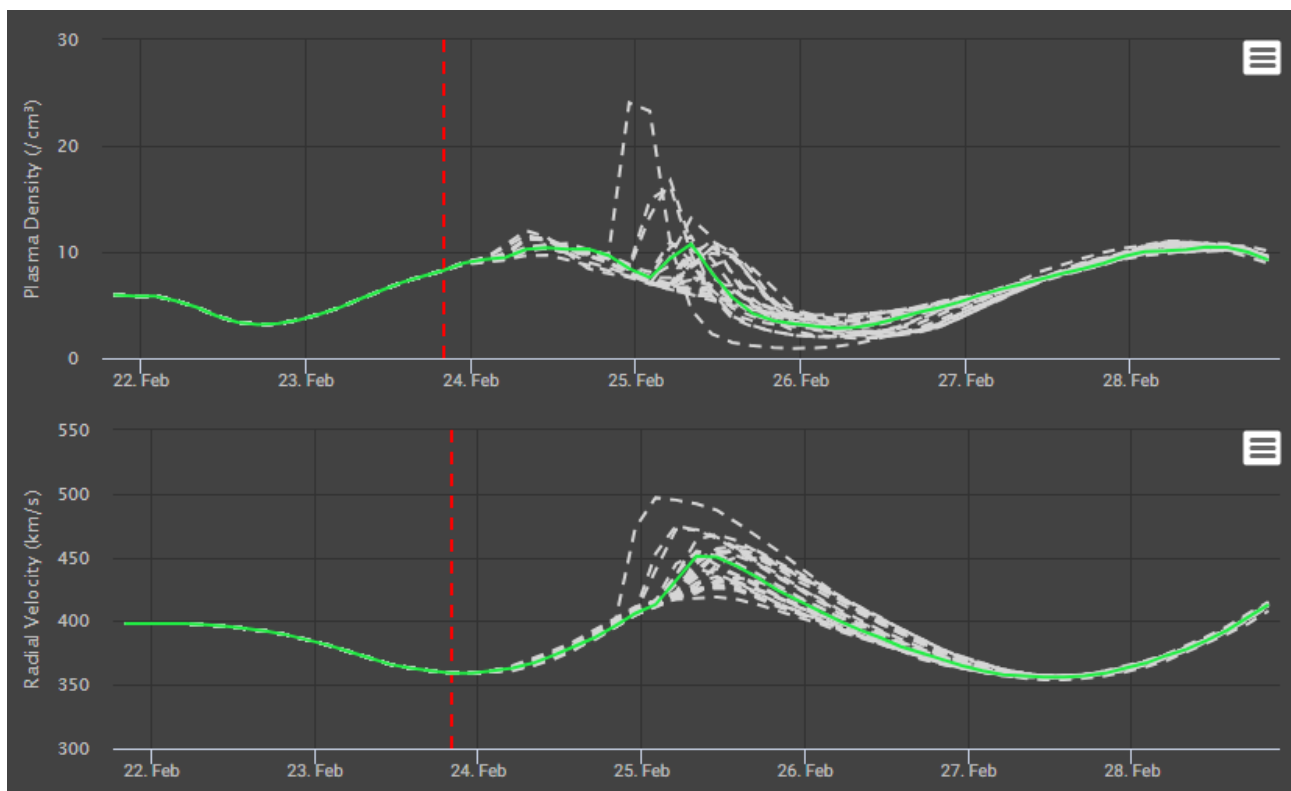
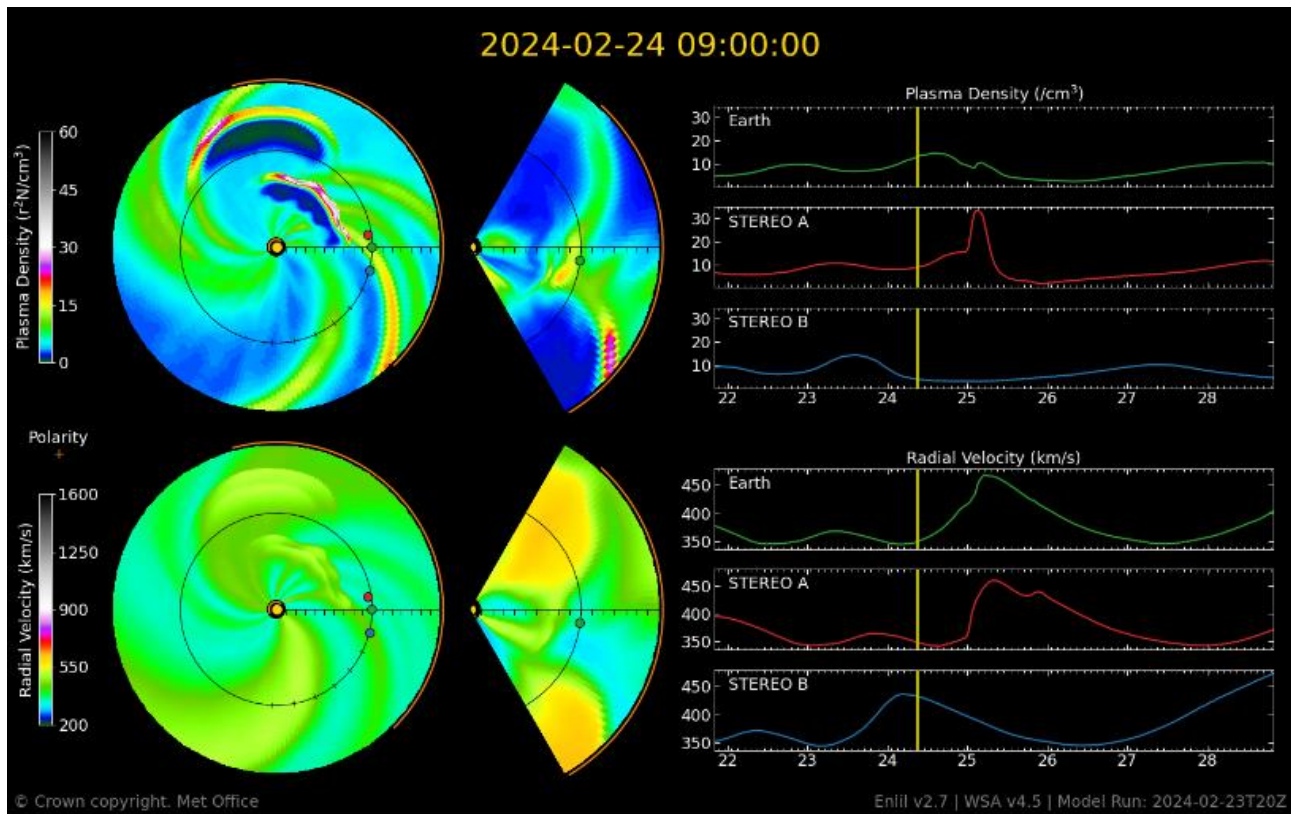
Geomagnetic activity is forecast to remain Quiet initially. An increase to Unsettled to Active is possible on Days 1 and 2, with a chance of G1/Minor storm intervals, particularly if connection to the high speed stream and the glancing blow from the filament CME occur at similar times. Geomagnetic activity is then expected to decline through Day 3, becoming largely Quiet again by Day 4.

| Geo-Magnetic Storm       | Level    | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|--------------------------|----------|------------------------|-------------------|-------------------|-------------------|-------------------|
| Probability (Exceedance) |          |                        | (%)               | (%)               | (%)               | (%)               |
| Minor or Moderate        | G1 to G2 | No                     | 10                | 30                | 10                | 1                 |
| Strong                   | G3       | No                     | 1                 | 1                 | 1                 | 1                 |
| Severe                   | G4       | No                     | 1                 | 1                 | 1                 | 1                 |
| Extreme                  | G5       | No                     | 1                 | 1                 | 1                 | 1                 |

**Geomagnetic Activity - Earthbound Coronal Mass Ejections**

| Date/time 21.5R (UTC) | Halo: Full or Partial | Source            | Source Location | Estimated Speed | Estimated Arrival Time | Comments               |
|-----------------------|-----------------------|-------------------|-----------------|-----------------|------------------------|------------------------|
| 22/0145               | Partial               | Filament eruption | NW              | 530 km/s        | 25/0300 UTC            | Glancing blow possible |

**Figure 2: MOSWOC Enlil and ensemble showing a potential CME glancing blow late 24 Feb / early 25 Feb, plus a high speed stream from CH01 arriving around the same time.**



## Radio Blackouts - X-Ray Flares:

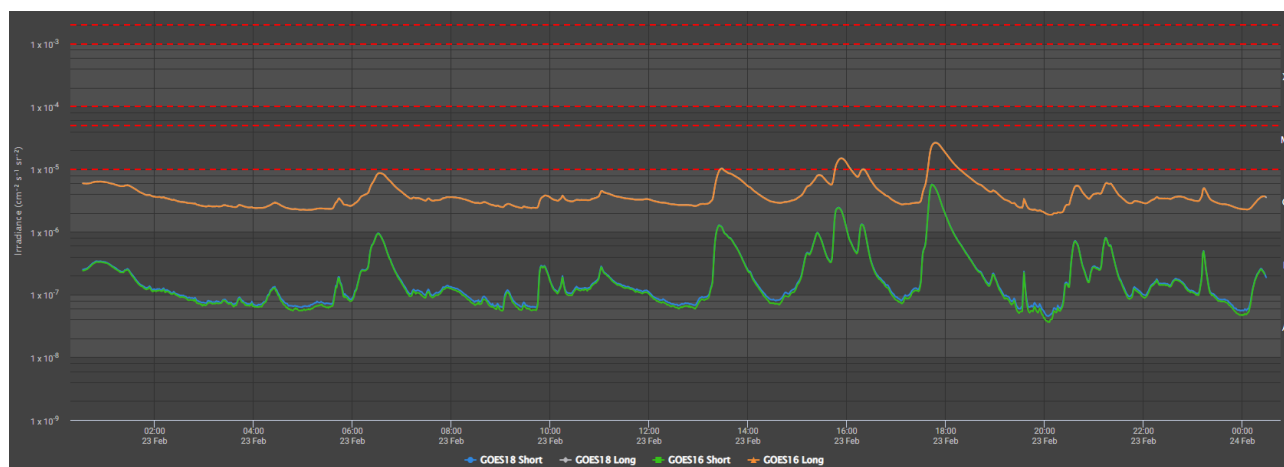
Solar activity has been Moderate over the past 24 hours, with the largest flare M2.6 peaking at 23/1747 UTC from AR3590 in the northeast, which was also recently responsible for the largest flare of the solar cycle so far, alongside a couple of smaller X-flares.

There are currently eight sunspot regions on the visible disc. AR3590 remains, by far, the largest and most complex region. There has been rearrangement of the spots within its intermediate spot, with a couple of delta spots, but also some signs it may be increasing in complexity. There remains significant looping evident in SDO AIA imagery, with further large flares possible from this region. The remaining regions are much smaller and appear simpler, however, AR3591 close to the southeast limb likely contains the remnants of the previously active Ex-AR3575. This and two further regions close to the eastern horizon may reveal more complexity as they rotate into clear view on the disc.

For now activity is forecast to remain Moderate to High, with occasional M-class flares expected and a chance of further isolated X-class flares, particularly in the short term, from AR3590. The risk of X-flares is allowed to decline towards more expected statistical levels during the period pending further developments of AR3590.

| X Ray Flares | Level               | Past 24 Hours<br>(Yes/No) | Day 1<br>(00-24 UTC) | Day 2<br>(00-24 UTC) | Day 3<br>(00-24 UTC) | Day 4<br>(00-24 UTC) |
|--------------|---------------------|---------------------------|----------------------|----------------------|----------------------|----------------------|
| Probability  |                     |                           | (%)                  | (%)                  | (%)                  | (%)                  |
| Active       | R1-R2<br>M Class    | Yes                       | 75                   | 75                   | 70                   | 70                   |
| Very Active  | R3 to R5<br>X Class | No                        | 40                   | 30                   | 20                   | 20                   |

Figure 3: X-ray flux at GOES16 and 18, showing several M-flares in the last 24 hours.



## Solar Radiation Storms - (High Energy Protons):

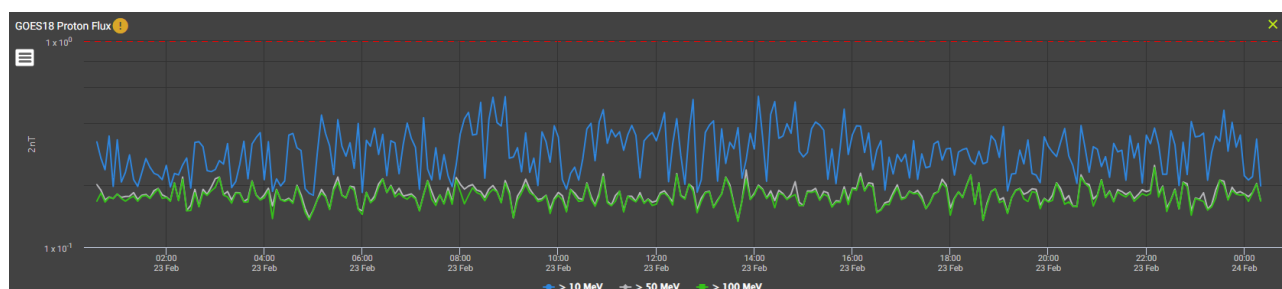
GOES18 high energy (greater than 10MeV) proton flux is slightly above normal background levels, but well below the S1/Minor Radiation Storm threshold.

AR3590 will become an increasing source of potential proton response as the region moves into the western hemisphere early on Day 2 (25 Feb). Particularly given its recent history of X-flares, there is a slight but increasing chance of S1/Minor Radiation Storms from this region, assuming it produces further large flares.

| Radiation Storms            | Level<br>( $\text{cm}^{-2} \text{sr}^{-1} \text{s}^{-1}$ ) | Past 24 Hours<br>(Yes/No) | Day 1<br>(00-24 UTC) | Day 2<br>(00-24 UTC) | Day 3<br>(00-24 UTC) | Day 4<br>(00-24 UTC) |
|-----------------------------|------------------------------------------------------------|---------------------------|----------------------|----------------------|----------------------|----------------------|
| Probability<br>(Exceedance) |                                                            |                           | (%)                  | (%)                  | (%)                  | (%)                  |
| Active                      | $\geq \text{S1}$                                           | No                        | 15                   | 20                   | 20                   | 25                   |
| Very Active                 | $\geq \text{S3}$<br>*                                      | No                        | 1                    | 1                    | 1                    | 1                    |

\*  $\text{S3} \geq 10 \text{ MeV} \geq 1000 \text{ pfu}$  and / or  $\geq 50 \text{ MeV} \geq 10 \text{ pfu}$ . (pfu =  $\text{cm}^{-2}\text{sr}^{-1}\text{s}^{-1}$ )

**Figure 4: Proton flux at GOES18, showing 10MeV proton flux just above normal background, but well below the S1/Minor Radiation storm threshold.**



## High Energy Electrons Event ( $\geq 2\text{MeV}$ ):

High energy electron flux (greater than 2MeV) is currently at background levels. The expected high speed stream from CH01/-, arriving on Days 1 or 2 (24-25 Feb), may give an increase in the electron flux, but this is quite dependent on how much geomagnetic activity we see from this feature (and any potential glancing CME blow at the same time). There is the possibility of an increase in electron flux through Days 3 and 4 (26-27 Feb), perhaps to high levels, but confidence is low.

Electron fluence values are expected to remain below the Active ( $1\text{e}8$  integrated pfu) threshold during much of this period, but with a possible rising trend later in the period. There is just a slight chance of reaching Active by Day 4. MOSWOC REFM is showing a below Active trend through the next three days, which seems reasonable at first, but may be slightly underestimating fluence by the end of its forecast period.

| GEO Electron Environment | Level ( $\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$ ) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|--------------------------|-----------------------------------------------------------|------------------------|-------------------|-------------------|-------------------|-------------------|
| Probability (Exceedance) |                                                           |                        | (%)               | (%)               | (%)               | (%)               |
| Active                   | $\geq 2 \text{ MeV}$<br>$\geq 1 \times 10^8$              | No                     | 1                 | 1                 | 5                 | 10                |
| Very Active              | $\geq 2 \text{ MeV}$<br>$\geq 1 \times 10^9$              | No                     | 1                 | 1                 | 1                 | 1                 |

Figure 5: MOSWOC REFM showing a below Active forecast for the next three days.

